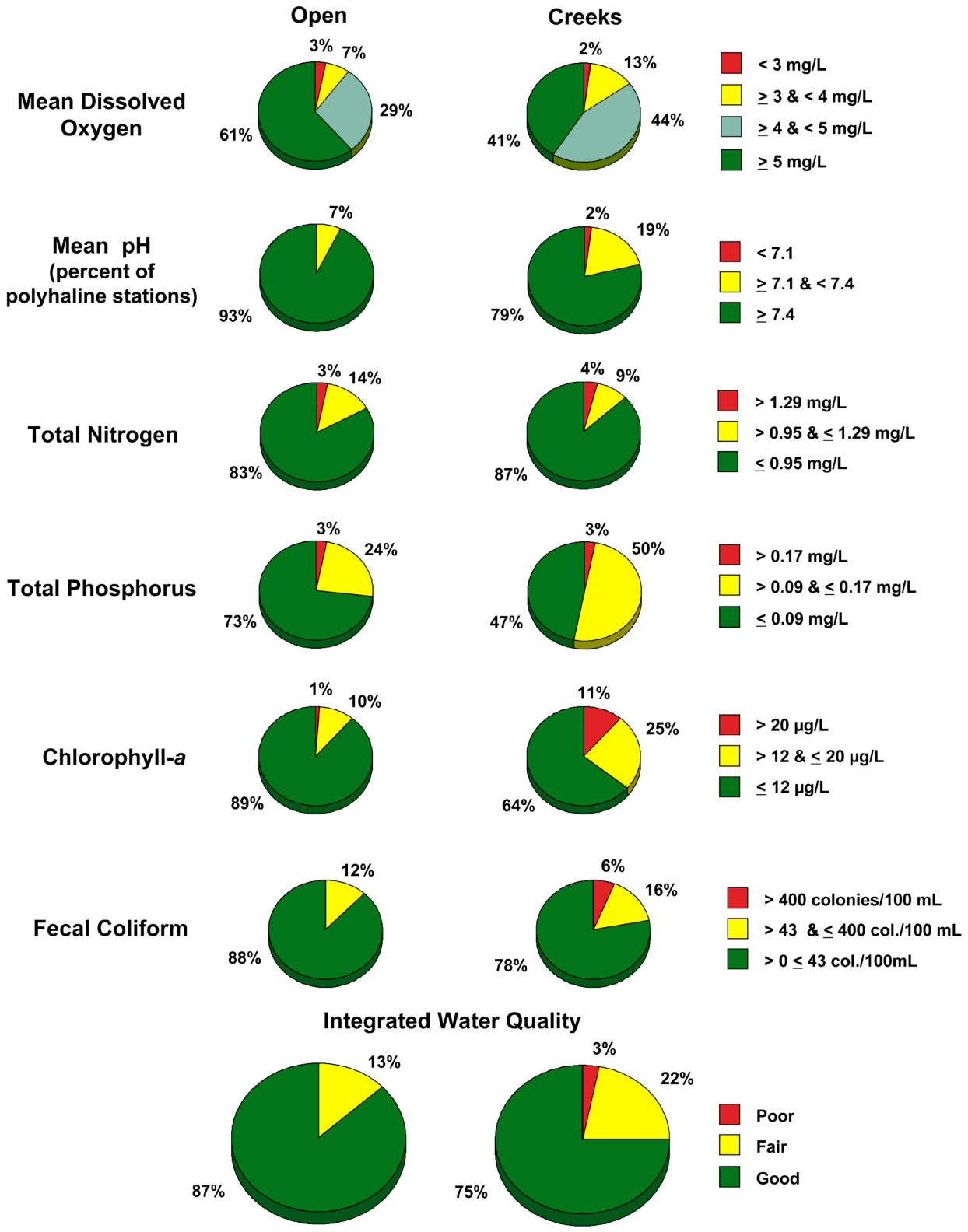

Figure 3.2.2. Comparison of the percent of the state's coastal habitat that represented various water quality conditions for selected water quality parameters and for the integrated water quality index.

The overall average pH observed in 2003-2004 based on the 25-hr measures was 7.3 in tidal creek habitats and 7.6 in polyhaline open water habitats, with approximately 79% of the state's polyhaline tidal creek habitat and 93% of the open water habitat having good pH conditions (Figure 3.2.2, data online). Criteria for lower salinity waters are still not available using the approach developed by SCECAP. As with the previous surveys, the mean instantaneous pH of surface waters within each habitat was within 0.1 pH unit of the mean bottom pH based on the continuous measurements. All mean values were also very similar to the averages observed in the 1999-2000 and 2001-2002 surveys (Van Dolah *et al*., 2002a, 2004a). Mean pH values were significantly lower in the tidal creek habitats compared to the open water habitats ($p < 0.001$) with a higher percentage of the state's polyhaline creek habitat having pH values considered to be only fair or poor compared to polyhaline open water habitat (Figure 3.2.2). Similar trends were noted in the previous two surveys (Van Dolah *et al*., 2002a, 2004a). Additionally, five tidal creek stations (RT032031, RT032046, RT032052, RT042062, RT042084) and two open water stations (RO036049, RO036054) had 25-hr pH means below the minimum (6.5) criteria established by SCDHEC. The locations of sites that had moderately low to very low pH values are provided in Appendix 2.

Nutrients

Nutrient concentrations in estuarine waters can become high due to runoff from upland urban and suburban developments, agricultural fields adjacent to estuarine habitats, riverine input of nutrient-rich waters from inland areas, and atmospheric deposition. High nutrient levels can lead to eutrophication of estuarine waters resulting in excessive algal blooms (including harmful algal species), decreased dissolved oxygen, and other undesirable effects that adversely affect estuarine biota (Bricker *et al*., 1999). Currently, there are no state standards in South Carolina estuarine waters for the various forms of nitrogen (except ammonia) and phosphorus. Therefore, the SCECAP data are compared to SCDHEC's historical database (SCDHEC, 1998a) to identify waters showing evidence of elevated nutrients. Values below the 75th percentile of the historical database are considered to be good, values above the 75th percentile and below the 90th percentile are considered to be moderately elevated (fair), and values above the 90th percentile are considered to be high (poor).

Nitrogen:

Total nitrogen (TN), as measured by the SCDHEC laboratory, is best represented by the sum of nitrate-nitrite and total Kjeldahl nitrogen (TKN). Based on historical SCDHEC (1998a) data, TN values ≤ 0.95 mg/L are considered to be good. Values > 0.95 mg/L and < 1.29 mg/L are considered to be fair since they are above the upper 75th percentile of the historical records and below the 90th percentile of those records. Values above 1.29 mg/L are considered to be poor since they represent the upper 90th percentile of the historical records.

In 2003-2004, the mean concentration of TN was 0.67 mg/L among the tidal creek sites and 0.66 mg/L among the open water sites. There was no significant difference between mean TN values observed in the tidal creek versus open water habitat ($p = 0.596$), which was also the case in the 2001-2002 survey, but not in the 1999-2000 survey when tidal creeks had a significantly higher nitrogen concentration compared to open water habitat. Approximately 93% of the nitrogen was in the form of TKN (organic fraction plus ammonia) when all stations were considered collectively. Mean nitrate-nitrite values in the creeks and open water sites were only 0.03 and 0.05 mg/L, respectively, which was similar to the values observed in the previous surveys.

Using the sum of the detectable values for nitrate-nitrite and TKN as an indication of TN enrichment, about 83% of open water habitat and 87% of tidal creek habitat had nitrogen levels indicative of good conditions. Fourteen percent of the state's open water habitat and 9% of the state's creek habitat had moderately elevated TN concentrations, considered to be fair (Figure 3.2.2, data online). Additionally, 3% of the open water habitat and 4% of the creek habitat had nutrient values considered to be poor. The percentage of the state's estuarine habitat with fair or poor TN concentrations was higher than observed in either the 1999-2000 or 2001-2002 surveys (Figure 3.2.3). This probably reflects the effects of increased runoff from upland habitat as compared to the drought period of the previous two surveys. Sites with very high TN concentrations were located in a creek in Clark Sound

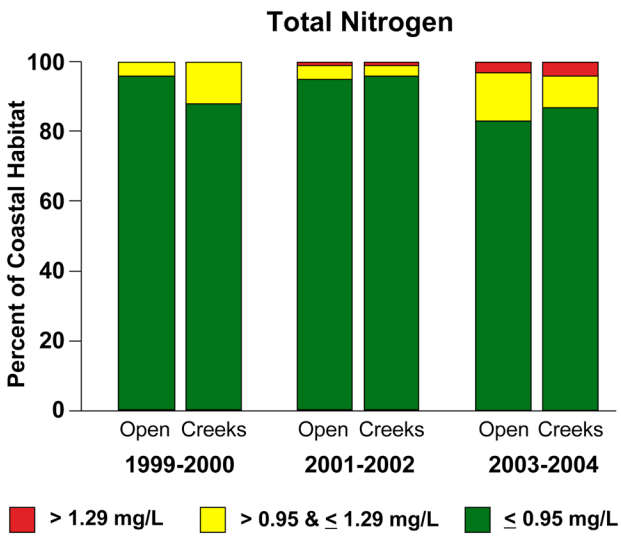

Figure 3.2.3. The percent of the state's coastal habitat representing various TN that are considered to be normal (green), fair (yellow), or poor (red) values relative to SCDHEC historical data during the three survey periods conducted to date.

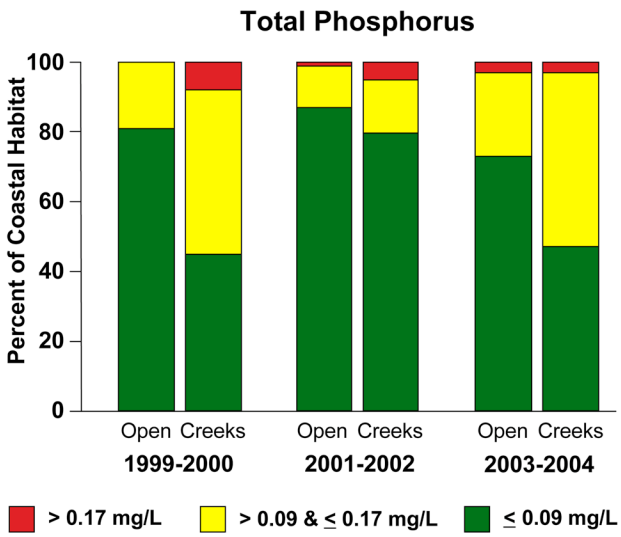

Figure 3.2.4. The percent of the state's coastal habitat representing various TP concentrations that are considered to be normal (green), fair (yellow), or poor (red) values relative to SCDHEC historical data during the three survey periods conducted to date.

off of Charleston Harbor (RT032050), the Intracoastal Waterway at Goat Island (RO036050), the Ashepoo River (RO036152), Winyah Bay at the mouth of the PeeDee River (RO046062), near Belle Isle Gardens (RO046064) and in the Ashley River (RT042192) near Middleton Gardens (Appendix 2). None of these sites had elevated concentrations of chlorophyll-*a*, another measure of possible estuarine eutrophication (see Chlorophyll-*a* section).

Phosphorus:

Based on SCDHEC historical survey data (SCDHEC, 1998a), total phosphorus (TP) levels ≤ 0.09 mg/L are considered to be good. TP concentrations > 0.09 and ≤ 0.17 mg/L represent concentrations above the 75th percentile and below the 90th percentile of historical records and are considered to be fair and. Concentrations > 0.17 mg/L are considered to be poor since they represent the upper 90th percentile of the historical observations. The mean TP measured by SCDHEC in 2003-2004 was 0.10 mg/L at the creek sites and 0.07 mg/L at the open water sites (data online). In contrast to the previous surveys in 2001-2002, this difference was statistically significant ($p = 0.002$) and comparable to the means observed during our first survey period in 1999-2000. Only 73% of open water habitat and 47% of tidal creek habitat had TP concentration considered to reflect good conditions. However, only 3% of the state's creek and open water habitat had TP concentrations that exceeded the 90th percentile (the threshold for poor conditions) of the SCDHEC historical database (SCDHEC, 1998a; Figure 3.2.2). The percentage of the state's coastal creek and open water habitat that was considered fair or poor with respect to TP concentrations was substantially greater than observed in 2001-2002, but not very different from the 1999-2000 survey (Figure 3.2.4). The relationships between changes in estuarine TP concentrations, regional rainfall patterns and

The upper Ashley River is home to several of South Carolina's historic plantation houses and managed gardens. Photo credit: Susan Tobias

anthropogenic inputs remains unclear and deserves further attention.

Tidal creek sites with very high TP concentrations were located in the upper Ashley River near Runnymede Plantation and Middleton Gardens (RT032046, RT041294; Appendix 2). This latter creek also had very high total nitrogen concentrations. Open water sites with very high TP concentrations were near the mouth of the Pee Dee River and in Winyah Bay near Belle Isle Gardens (RO046062, RO046064; Appendix 2).

Chlorophyll-a

Our measure of phytoplankton biomass in the water column is based on chlorophyll-*a* concentrations. Other phytoplankton pigments were also examined using HPLC analyses to determine phytoplankton composition (see Section 3.4). High chlorophyll-*a* concentrations provide an indication of possible estuarine eutrophication since phytoplankton respond rapidly to enriched nutrient concentrations and can form blooms that result in poor water quality (e.g., low DO, large DO variations) and the presence of harmful algal species. For SCECAP, chlorophyll-*a* concentrations $\leq$ 12 µg/L are considered to be good. Chlorophyll-*a* values > 12 µg/L represent the upper 75th percentile of all chlorophyll-*a* concentrations measured by the SCECAP program and are considered to be only fair. Chlorophyll-*a* concentrations above 20 µg/L are considered to be high or poor based on criteria or guidelines published by Bricker *et al.* (1999) and the USEPA (2004).

The mean chlorophyll-*a* concentration was 11.8 µg/L in creek habitats and 7.6 µg/L at the open water sites. This difference was statistically significant ($p < 0.001$), but both means represent relatively low concentrations based on the SCECAP database (i.e., < 75th percentile). Using SCECAP criteria, 11% of the state's tidal creek and 1% of the open water habitat had chlorophyll-*a* concentrations considered to be poor (Figure 3.2.2). The slightly higher chlorophyll concentrations in tidal creeks may be reflective of the higher nutrient concentrations observed in the creeks. It may also reflect possible re-suspension of benthic algae from the creek bottoms and nearby marsh surfaces.

An analysis of the relationships between total nutrient concentrations and chlorophyll-*a* concentrations using all six years of available data showed very little correlation between TN and chlorophyll-*a* concentrations (r^2 =0.0185) or between TP and chlorophyll-*a* concentrations (r^2 = 0.0143) (Figure 3.2.5). This is similar to the findings obtained by Van Dolah *et al.* (2004a) in previous survey periods of estuarine habitats. Similarly, Brock (2005) could find no relationships between phosphorus and chlorophyll-a concentrations in brackish stormwater ponds in SC. Therefore, the poor relationships between TN and TP and chlorophyll-a suggest a need to reconsider the utility of using nutrient concentrations as indicators of eutrophication. The lack of a good correlation with either nutrient parameter is likely due to a combination of nutrient-algae dynamics and the high tidal amplitude present in South Carolina estuaries, the latter of which reduces formation of blooms that might otherwise occur in more stagnant waters or in estuaries that have much lower tidal flow.

Fecal Coliform Bacteria

Fecal coliform bacteria are sampled as a measure of potential health hazard in estuarine waters related to primary contact recreation such as swimming and shellfish harvesting. State fecal coliform standards to protect primary contact recreation requires a geometric mean count that does not exceed 200 colonies/100 mL based on five consecutive samples in a 30-day period and no more than 10% of the samples can exceed 400 colonies/100 mL. To protect for shellfish consumption, the geometric mean shall not exceed 14 colonies/100 mL and no more than 10% of the samples can exceed 43 colonies/100 mL (SCDHEC, 2004). Since only a single fecal coliform count is collected at each site during SCECAP surveys, compliance with the standards cannot be strictly determined, but the data can provide some indication of whether the water body is likely to meet standards. For SCECAP, we consider any sample with $\leq$ 43 colonies/100 mL to be good. Samples with > 43 colonies/100 mL and < 400 colonies/100 mL represent fair conditions (i.e., potentially not supporting shellfish harvesting) and any sample with > 400 colonies/100 mL represents poor conditions (i.e., potentially not supporting primary contact recreation).